Notes on life history of *Oecophylla smaragdina* (Fabricius) and its potential as biological control agent

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Abstract

Studies on life history of weaver ant *Oecophylla smaragdina* and its potential as biological control agent were carried out in Horticulture Department, Punjabi University, Patiala. Parameters such as life history, nest building behavior, caste composition, and potential of *Oecophylla smargadina* as biological control agent were studied.To study the effect of weaver ant as pest control agent, 127 Mango trees and 38 Citrus trees were observed for nests of weaver ant. Out of these, 80 mango trees and 25 citrus trees were found with *Oecophylla* nests, number of nests per tree was also taken into account. Average yield per tree with and without ant nests was calculated.

Keywords: *Oecophylla smaragdina, Life history, Biological control, India.*

Introduction

Among the thousands of social insects a few deserve to be called classic, because of certain remarkable features in their behavior have prompted unusually careful and thorough studies. The honey bees, the bumble bees, the driver ants, the army ants, the leafcutter ants, the slave-maker ants, and the fungus growing termites are all examples of classic social insects. *Oecophylla* belongs to the subfamily Formicinae, provisionally placed in a tribe of their own, Oecophyllini. *Oecophylla* is a relatively old genus with 11 fossil species being reported from the Oligocene and Miocene deposits (Azuma *et al.*,2002). The species of *Oecophylla* lack a functional sting. But these industrious animals inflict a painful bite which is aggravated by irritating chemicals secreted from their abdomen. The construction of communal silk nests has clearly contributed to the success of *Oecophylla* weaver ants. With their huge colonies and their ability to construct nests almost anywhere, the *Oecophylla* weaver ants have achieved a close control of their environment.

Two closely related living species of the genus *Oecophylla* are; *Oecophylla longinoda* found in Sub-Saharan Africa and *Oecophylla smaragdina* found in India, South-East Asia and Australia. *Oecophylla smaragdina*, also known as the yellow citrus ant, has been used in China for almost 1700 years to protect citrus fruit against damage by insect pests. Use of ants as biological control of insects was widespread in the citrus orchards of Sihui, Qingyuan, and Panyu districts around Canton, as well as in Caoching and Gaozhou.

They feed on various insects that attack the orange, tangerine, lemon, and pomelo trees and their fruit, supplement their diet with carbohydrate rich honey dew excreted by small insects (Hemiptera). Whole orchards can be colonized by securing a nest on one tree and then connecting it to adjacent trees with bamboo strips. The strips serve as bridges for the ants to build new nests in nearby trees.

The weaver ants evidently combat the diseases by attacking the bugs. The *Oecophylla* workers are also particularly effective in hunting insects that feed on the tissue and sap of trees.

Although the weaver ant *Oecophylla* is the first written record of biological control, dating from 304 A.D, there have been fewer than 70 publications on this predator as a biological control agent in Asia. Classical biological control has achieved some tremendous successes over the past century, yet scientists recognize that the opportunities are limited and that greater attention is needed to increase the impact of native natural enemies (Greathead, 1991). A review of manipulative field studies showed that, in 75% of cases, generalist predators, whether single species or species assemblages, reduced pest numbers significantly

(Symondson *et al.*, 2002). Other useful criteria for ants as biological control agents include broad habitat range and choice of species that are unlikely to be out-competed by other ants (Majer, 1986).

Holldobler and Wilson (1977) studied the social establishment and maintenance of territory by African weaver ant *Oecophylla longinoda*. They explained that odour trails laid from rectal gland of worker ants were used to recruit nest mates to previously unoccupied space in the nests. Begg (1977) studied the effect of cyclone "Tracy" on the *Oecophylla smaragdina* in deciduous vine thickets near Darwin.

Keeping in view the above mentioned facts, the present study was designed to acquire more knowledge about the weaver ant *Oecophylla smaragdina* and its potential as biological control agent in our country.

Materials and Methods

1. For this study related to weaver ant *Oecophylla smaragdina,* Horticulture Department of Punjabi University, Patiala was selected.
2. Nests of *Oecophylla smaragdina* were located on Mango and Citrus trees and observations related to study were carried from September, 2007 to August, 2008.
3. Parameters such as life history, nest building behavior, caste composition, and potential of *Oecophylla smargadina* as biological control agent were studied.
4. Data pertaining to fruit yield, w.r.t. number of trees with ant nests etc. have been compared with trees without weaver ant nests.
5. Pests infecting selected trees were identified to get a broader view of the effect of weaver ant.
6. For better correlation, the data pertaining to pesticides sprayed have also been taken into consideration.
7. Meteorological data (average temperature, relative humidity) during the period of study was procured from Meteorological Department of Punjabi University, Patiala.

Results and Discussion

Study on life history of *Oecophylla smaragdina* and its role as biological control agent was carried out at Horticulture Department, Punjabi University, Patiala from September, 07 to August, 08.

For clarity, the results and discussion are dealt here in two parts, i.) covering the life history and nesting behavior of *Oecophylla smaragdina* and ii.) its role as biological control agent.

1. Life history and Nesting Behavior of *Oecophylla smaragdina*

Castes of *Oecophylla smaragdina*

The castes of this species are easily differentiated into small and large workers, males and females (Table-3). Major workers (adults) were found to be 8mm in length compared to 5mm in case of minor workers. Pupae of major workers and minor workers measured 4mm and 3mm in length respectively. The small workers are seldom found outside the immediate proximity of the nests; they may solicit honey-dew producing Homoptera within the nests, but their main function was found to attend the developing brood and the sexual forms. The large workers attend honey-dew producing Homoptera outside the nests, forage on the ground, kill other insects for food and defend the colony. They are the only form that builds the nests and shelters over clusters of Homoptera, they also attend the brood and carry it from nest to nest within the colony. The virgin sexual form posses wings, but the gravid queen is dealated (wingless) and has an abdomen greatly distended with developing ova.

Nesting habits of *Oecophylla smaragdina*

Oecophylla smaragdina builds arboreal nests and has never been observed to nest or forage beneath the soil surface. During present study, the colonies of *Oecophylla smaragdina* were observed on citrus and mango trees. Generally the choice of host plant appears to depend partly on the ease with which the leaves can be used to form nests and partly on the ability of the host plant to support suitable Homoptera from which the ant can obtain honey-dew for food. During the study *Amritodus atkinsoni* (Lethiery) was found associated with ant nests on citrus and mango trees.

It was observed that day before nest building, the large workers crawled slowly over the nest areas in order to assess the number of leaves to form nest. For building nests, larger workers draw individual leaves together, forming chains of up to twelve workers to bridge the gaps. The chains are formed by each ant gripping with its mandibles the very long petiole of the ant in front and leaves are gripped by the mandibles and by the well developed tarsal claws. About two hundred workers in chains of up to nine individuals were observed drawing a pair of leaflets together and the manner in which all chains coordinated in pulling together was most striking. After the leaves were drawn together, they were held in position by workers, while other larger workers, carrying larvae in their mandibles, proceeded to secure the edges together with silk secreted by the larvae.

Nests were observed for five months on 5 trees of citrus. It was seen that there were total of 20 nests at the start of the season and 40 at the end. Average of 5-6 nests were built per tree/season. Each nest was

occupied for an average of eighty-five days and deserted when most of the leaves of which it was built, died.

Composition of *Oecophylla smaragdina* nests

Eighteen nests, 9 each from mango and citrus trees were examined for their contents. It consisted of egg, larvae and pupae (brood), major and minor workers and sometimes depending upon season

Table-1: Showing average temperature and percentage of relative humidity (R.H.) recorded during months of the year (2007-2008)

Months	Temperature (°C)		Relative Humidity %
	Maximum	Minimum	
September,07	31.9	20.3	91.86
October,07	33.21	16.60	81.83
November,07	28.29	9.6	89.56
December,07	18.3	1.08	93.09
January, 08	17.26	2.6	86.19
February,08	23.4	3.1	89.51
March,08	31.0	25.86	80.29
April,08	22.72	14.56	60.96
May,08	38.28	24.32	57.80
June,08	36.06	22.3	85.50
July,08	34.09	25.2	89.32
August,08	32.7	24.0	90.16

Table-2: Mean number of workers and brood of Oecophylla smaragdina within nests built on Mango and Citrus trees

Tree	No. of nests examined	Mean number of workers per nest	Mean number of brood per nest
Mango	(3 Small)	707	245
	9 (3 Medium)	4994	4336
	(3 Large)	13,383	8981
Citrus	9	719	298

Table-3: Average length of Major and Minor worker adults and pupae of *Oecophylla smaragdina*

Caste	Average length (mm)
Major worker (adult)	8 mm
Minor worker (adult)	5 mm
Major worker (pupae)	4 mm
Minor worker (pupae)	3 mm

Table-4: Pests of Mango and Citrus trees

Pest of Mango	Insect order	Family	Species Common name
1. *Amritodus atkinsoni* (Lethiery)	Hemiptera	Cicadellidae	Mango-hopper
2. *Drosicha mangiferae* (Green)	Hemiptera	Margarodidae	Mango Mealy-bug
3. *Batocera rufomaculata* DeGeer	Coleoptera	Cerambycidae	Mango Stem-borer
4. *Sternochetus mangiferae* (Fabricus)	Coleoptera	Curculionidae	Mango-stone Weevil
5. *Bactrocera dorsalis* (Hendel)	Diptera	Tephritidae	Mango Fruit-fly
6. *Aceria mangiferae* Sayed	Acari	Eriophidae	Mango-bud Mite
Pest of Citrus			
1. *Diaphorina citri* Kuwayana	Hemiptera	Aphalaridae	Citrus Psylla
2. *Phyllocnistis citrella* Stainton	Lepidoptera	Phyllocnistidae	Citrus Leaf-miner
3. *Dialeurodes citri* (Ashmead)	Hemiptera	Aleyrodidae	Citrus Whitefly
4. *Aleurocanthus woglumi* Ashby	Hemiptera	Aleyrodidae	Citrus Blackfly
5. *Papilio demoleus* Linnaeus	Lepidoptera	Papilionidae	Citrus caterpillar
6. *Ophideres* sp.	Lepidoptera	Noctuidae	Fruit-sucking Moths
7. *Desineura citri* Grover	Diptera	Cecidomyiidae	Citrus Blossom Midge

Table-5: Pests of Mango

Name of Pest	Period of Occurrence	Parts attacked and damage caused	Insecticides used
1. *Amritodus atkinsoni* (Lethiery) Mango-hopper	Active throughout the year. Maximum damage caused during Feb.-April	Nymph and adults are found clustering on the inflorescence and suck the sap during spring. Infested flowers shrivel, turn brown and fall off	Malathion or Endosulfan
2. *Drosicha mangiferae* (Green) Mango Mealy-bug	This pest is active from December to May and spend rest of the year in egg stage	Damage is caused by nymphs and wingless females. They suck plant juice, causing tender shoots and flower to dry up.	500 ml of Methyl parathion 50 EC in 250 lt. of water/ha.
3. *Batocera rufomaculata* DeGeer Mango Stem-borer	Spring season	Not very common, Damage is caused by the grubs killing branch or sometimes entire tree	Stems are injected with 4 ml of methyl parathion 50 EC mixed in 1 lt. of water into the hole and plugged with mud.
4. *Sternochetus mangiferae* (Fabricius) Mango-stone Weevil	Life cycle starts with formation of mango fruits. Weevil lay eggs in fruits (May)	Not a serious pest, the injury is caused by the larvae feeding on the pulp.	The Weevil being an internal feeder throughout its life cycle cannot be controlled by pesticides
5. *Bactrocera dorsalis* (Handel) Mango Fruit-fly	Active during summer months	Damage is caused by grubs which feed on pulp making the fruit unfit for human consumption	1.25 lt. of Malathion 50 EC + 12.5 Kg Sugar in 1250 lt. of water per ha.
6. *Aceria mangiferae* Sayed Mango-bud Mite	Peak in population has been observed in months of February, June and July	The bud mite sucks the sap from inside the buds and causes necrosis of tender tissues	Spray of 1 lt. of dimethoate 30 EC in 250 lt. of water/ha. during summer

Table-6: Pests of Citrus

Name of Pest	Period of Occurrence	Parts attacked and damage caused	Insecticides used
1. *Diaphornia citri* Kuwayana Citrus Psylla	Throughout the year. Nymph occur during months of April to September	Most destructive pest of citrus. Nymph are harmful they possess sharp, piercing mouth parts; suck the cell-sap in millions. The leaf-bud, flowers and leaves may wilt and die.	1.70 lt. of dimethoate 30 EC or 1.25 lt. of malathion 50 EC or 500 ml of fenitrothion 50 EC in 250 lt. of water/ha during Feb.-March (Springflush) May-June (before rainy season) and July-August (after rainy season)
2. *Phyllocsnistis citrella* Stainton Citrus Leaf-miner	Active during late spring or summer season	Larvae cause damage to young leaves by making zigzag slivery mines. The injured epidermis takes the shape of twisted silvery galleries.	125 ml of fenvalerate 20 EC or 250 ml cypermethrin 10 EC or 875 ml of decamethrin 2.8 EC or 370 ml of monocrotophos 40 EC in 250 lt. of water/ha at fortnightly intervals
3. *Dialeurodes citri* (Ashmead) Citrus Whitefly	Active during March-April and again in August-Sept.	The damage is caused by adults as well as nymphs.	1140ml of Thiodon 35EC (endosulfan) in 500 lt. of water/acre during April-may and again September - October.
4. *Aleurocanthus woglumi* Ashby Citrus Blackfly	Active during March-April and July-October.	Both adult and nymphs suck plant sap resulting in curling of leaves and premature fall of flower buds and developing fruits	1140ml of Thiodon 35EC (endosulfan) in 500 lt. of water/acre during April-may and again September- October.
5. *Papilio demoleus* Linnaeus Citrus Caterpillar	Activity synchronizes with the growth of citrus plants in April and Aug-Sept.	Damage is caused by young larvae which feed on fresh leaves and terminal shoots	750ml Thiodon 35EC (endosulfan) in 500lt.of water/acre.
6. *Ophideres* sp. Fruit-sucking Moths	Minor pest during Spring and July-October.	Cause damage in adult stage. Punctures fruit for sucking juice.	2.5 kg of Carbaryl 50 WP in 500 lt. of water/ha at time of maturity of fruits
7. *Dasineura citri* Grover Citrus Blossom Midge	Feb.-March (2-3) generations are completed during flower period	The attack of this orange fly pest is heavy during Feb.-March and the infested blossom looks abnormal in shape. The attacked buds and flowers when Shaken drop off easily, reducing the fruit bearing capacity of the trees	1.70 lt. of dimethoate 30 EC or 1.4 lt. of Phosalone 35 EC in 1250 lt. of water per ha.

* EC = Emulsifiable Concentrate, ** WP = Wettable Powder

Table-7: Types of Insecticides Used

Insecticides	WHO Classification	Trees	Total Exp. (Rs.)/year
Organophosphates			
Methyl parathion	Extremely hazardous (Ia)	Mango	Rs. 559
Melathion	Moderately hazardous (II)	Citrus Mango	Rs.125 Rs. 691
Dimethoate	Moderately hazardous (II)	Citrus Mango	Rs.384 Rs. 2143
Phosalone	Moderately hazardous	Citrus	Rs. 241
Monocrotophos	Moderately hazardous	Citrus	Rs.171
Organo chlorine			
Endosulfan	Highly hazardous (Ib)	Citrus, Mango	Rs. 525
Carbamate			
Carbamyl	Highly hazardous (Ib)	Citrus Mango	Rs.186 Rs.1067
Pyrethroids			
Cypermethrin	Moderately hazardous	Citrus	Rs.126
Decamethrin	Moderately hazardous	Citrus	Rs.187
Fenitrothion	Moderately hazardous	Citrus	Rs.246
Fenvalerate	Moderately hazardous	Citrus	Rs.181
			Total: Rs. 6832

WHO Classification

Ia. Extremely hazardous
Ib. Highly hazardous
II. Modertately hazardous

Table-8: Categorization of trees with or without ant nests

No. of Mango trees	No. of Trees with Ant Nest	No. of Nests per tree (Average)	No. of Trees without nest.
127	80	20	47
No. of Citrus trees			
Malta (30)	20	8	10
Kinnow (8)	5	8	3

Table-9: Total yield pertaining to 2007-2008 at Horticulture Department

Fruit	Average Yield/Tree/Year	Total Yield at Horticulture Department, Punjabi University, Patiala pertaining to year 2007-2008
Mango (127)	75.4 Kg	9579.5 Kg
Citrus		
Malta (30)	17 Kg	510Kg
Kinnow (8)	40.3 Kg	323Kg

Table-10: Average yield per tree with and without ant nests

Trees	Average Yield/Tree (With ant nests)	Average Yield/Tree (Without ant nests)	Total Yield/ Year
Mango (127)	79.5Kg (6360 Kg)	67.5Kg (3219.5 Kg)	9579Kg
Kinnow (8)	43Kg (215 Kg)	36 Kg (108Kg)	323 Kg
Malta (30)	18 kg (360 Kg)	15 Kg (150 Kg)	510 Kg

dealate queens. The population was roughly estimated by counting the number of workers and brood in 9 nests each of citrus and mango trees. It has been observed that in medium sized nests the proportion of brood to the number of workers is almost same, but in case of small and large size nests, number of brood per nest is comparatively low (Table-2).

Nests were also examined at intervals for the presence of sexual forms. It was observed that during August and September, 07, winged male and female adults were found not more than 2-3 per nest. Most nests contained only worker adults and brood. In October, queen larvae and pupae, male pupae and small number of male and female adults were observed. Immature and adult sexual forms were found in large numbers during November, December, January and February. During February and March, dealated females (after nuptial flight) were found on vegetation. From March up to August, the process of nest building starts all over again and the nest during this period largely comprises of brood, immature adults of sexual forms, major and minor workers and dealate queen.

2. *Oecophylla smaragdina* as pest control agent

In Horticulture Department, Punjabi University Patiala, the main insect pests of Citrus and Mango trees were: Mango-hopper *Amritodus atkinsoni* (Lethiery) (Hemiptera: Cicadellidae), Mango Mealy-bug *Dorsicha mangiferae* (Green) (Hemiptera: Margarodidae), Mango Stem-borer *Batocera rufomaculata* DeGeer (Coleoptera: Cerambycidae), Mango-stone Weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionadae), Mango Fruit-fly *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), Mango–bud Mite *Aceria mangiferae* Sayed (Acari: Eriophidae) [Mango] (Table 4, 5); Citrus Psylla *Diaphornia citri* Kuwayana (Hemiptera: Aphalaridae), Citrus Leaf-miner *Phyllocnistis citrella* Stainton (Lepidoptera: Phyllocnistidae), Citrus Whitefly *Dialeurodes citri* (Ashmead) (Hemiptera: Aleyrodidae), Citrus Blackfly *Aleurocanthus woglumi* Ashby (Hemiptera: Aleyrodidae), Citrus Caterpillar *Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae), Fruit-sucking Moths *Ophideres* sp. (Lepidoptera: Noctuidae) and Citrus Blossom Midge *Desineura citri* Grover (Diptera : Cecidomyiidae) [Citrus] (Table 4 and 6).

The life history of these pests coincided with the fruit bearing period of the mango and citrus trees (Table 5 and 6). To control the pests of both trees various pesticides are in use in the experimental site. The pesticide treatment is generally carried out in the months of March and August respectively. The pesticides used by the Horticulture Department were found to be Organophosphates, Organochlorines, Carbamates and Pyrethroids. It has been observed that the above mentioned insecticides come under the extremely hazardous to moderately hazardous category of World Health Organization (WHO) (Table-7).

Keeping in mind the hazardous effects of these pesticides, an attempt was made to study the effect of weaver ant as pest control agent. For this purpose, number of mango and citrus trees were counted in the Horticulture Department and then the trees with ant nests and also number of nests per tree were identified (Table- 8). It was found that average yield/mango tree with ant nest was 79.5Kg compared to 67.5Kg/mango tree without ant nests. Similar results were found in case of Kinnow trees, 43Kg/tree with ant nests and 36Kg/tree without ant nests and Malta trees obeyed the same yielding 18Kg/tree with ant nests as compared to 15Kg/tree in the absence of ant nests. Insecticides were sprayed irrespective of the presence or absence of ant nests. But during present study, it was found that the incidence of these pest species was almost negligible on the trees occupied by weaver ants. Thus it was observed that these trees dominated in terms of quality and quantity of fruits.

These preliminary observations carried over a limited period of time indicate that weaver ant has a lot of potential as biological control agent in our country. Ant husbandry holds a lot of promise and its potential as biological control agent could be harnessed in India as well.

Still, we need to work on nest establishment/nest shifting of this peculiar ant so as to use it as an effective biological control resource. Finally, we need to generate awareness amongst horticulturists regarding its use so as to avoid hazardous effects of pesticides.

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